CHAPTER 13. RADAR AND AIR TRAFFIC CONTROL RADAR BEACON SYSTEM (ATCRBS) FREQUENCY ENGINEERING

1300. **POLICY**. All initial frequency engineering for new radar systems is done by ASR. Subsequent frequency changes as a result of RFI or relocations are done by the Regional FMO.

a. FAA is designated by NTIA as the national coordinator for 1030/1090 MHz and the 1215-1400 MHz, 2700-2900 MHz and the 9000-9200 MHz bands. As national coordinator, all users must coordinate with the FAA for systems in these bands. Upon coordinating with a field user of these systems, the Regional FMO will enter a coordination record into the automated frequency engineering system to "reserve" the frequency for the user. These coordinated requirements will be forwarded to ASR to confirm coordination and retained in the system for 90 days, after which the record will be purged by ASR if the application has not yet been received from the proposed user.

b. FAA, as the Chair of the AAG, is also responsible for the proper engineering and management of the 1030/1090 MHz pair. Upon coordination with users for new requirements on these frequencies, the FMO will enter a coordination record, as is done for the above radar bands, in order to reserve the frequency and the PRR.

c. All Next Generation (NEXRAD) (WSR-88D) and Terminal Doppler Weather Radar (TDWR) weather radar frequencies are engineered by ASR.

1301. **GENERAL ASSIGNMENT PROCEDURES**.

a. The selection of a frequency for a primary radar, Air Route Surveillance Radar (ARSR) for 1215-1400 MHz or Airport Surveillance Radar (ASR) for 2700-3000 MHz, is similar to the problem of squeezing a COMM or NAVAID facility into an already crowded spectrum. The major difference is the extremely large bandwidths required. For instance, an ARSR-1 or ARSR-2 has an emitted spectrum that extends considerably beyond the assigned band, although the spectrum beyond the immediate center frequency is over 40 dB suppressed and thus meets the NTIA standard. But in so doing, that broad spectrum can be a problem, considering the relatively high power at -40 dB from 4 megawatts peak plus antenna gain. Receivers in the reasonably near spectrum can be affected.

b. Radar receivers also have a decided effect on the assignment process. Even though a receiver may seem to have a bandpass that is extremely wide by COMM or NAVAID standards, it is necessarily so by the nature of radar reception. If it is an established radar system, it must be protected by any assignment of a new facility.

c. Most radars have two separate transmitters and receivers. Older radars operate only one transmit and receive (T/R) channel at a time. The other channel is normally tuned to another frequency and is used as a backup or an alternate system. For interference protection, it is desirable to separate the two frequencies as far as possible within the band. While as much frequency separation as possible is the goal, in most areas of the country, frequency congestion is so severe that the two channels must be assigned frequencies only a few MHz separated. Since the unused channel is kept "hot," some frequency separation is necessary to prevent interference to the operating channel.

d. Diplex radars operate both channels simultaneously, although their actual transmitting time is usually separated in time so that the transmitted pulse of one is off while the transmitted pulse of the other is firing. The difficulty for the FMO is that the nature of the system and the nontunable diplexers currently in use require a minimum frequency separation between the two channels (see paragraphs 1304-1308 for individual radar's minimum frequency separation). This provision puts heavy constraints on the FMO in replacing a frequency pair.

e. The pulse repetition rate (PRR) is the number of pulses of energy per second (pps) transmitted by the system and normally is the trigger for the associated ATCRBS interrogator.

f. The pulse repetition time (PRT) is that time in microseconds between the start of any two consecutive radar pulses. In numerical terms, PRT = 1/PRR and PRR = 1/PRT.

g. Radar Beacon Systems have changed over time from the original concept of simple detecting and ranging. The addition of a nondirectional but lower power simultaneously transmitting set of pulses has been used to reduce false targets caused by various sources. The system is called Side Lobe Suppression (SLS), and a later version, Improved SLS (ISLS). With the implementation of Specialized ATCRBS with discrete address capability (Mode S) and other monopulse radars, "sum and difference" patterns on the directional antenna are being used to enhance accuracy.

h. Other devices such as a Beacon False Target Eliminator (BFTE) and a "defruiter" to eliminate electronically undesired responses called False Returns Unsynchronized In Time (FRUIT) have had varying degrees of success. Newer versions for ever-improved ATCRBS performance currently include a direct access to only a single aircraft called Mode S.

i. The FMO also should be aware of airborne radar and altimeter frequency bands, such as 4200-4400 MHz, 5350-5470 MHz, 9300-9500 MHz and 13.25-13.45 GHz. From time to time, the FMO may be asked to assist in elimination of RFI for such systems.

1302. PRR ASSIGNMENT OF ATCRBS.

a. The ATCRBS is the heart of the entire NAS surveillance system. Unfortunately, it provides this key system through a single pair of frequencies, 1030 MHz (ground-to-air) and 1090 MHz (air-to-ground). The only method for discriminating between each ATCRBS facility is by the PRR (noting that ATCRBS PRR is really interrogations per second and not pulses per second). It is only the differences in PRR that permits all these systems to operate simultaneously. Since all the military IFF systems also operate on the same frequency pair, the critical task of engineering individual PRR's can be readily understood.

b. The best current method to keep PRR's from interfering with one another is to use a staggered PRR. It works on the basis of a crystal-controlled clock generating a fixed time base. Prearranged programming selects a PRT in sequence, followed by another but different period, and so on for 4, 5, 6 or 7 periods before repeating the whole sequence. Each such stagger system has several stagger groups. In so doing, the chance of hitting the exact time of an emitted pulse of another 1030 MHz interrogator is enormously decreased. The stagger sequence for ARSR's and ASR's and their associated ATCRBS are shown in various figures in following paragraphs.

c. The necessity for separating PRR's is that should two interrogators transmit at the same PRR and both illuminate the same aircraft simultaneously, both radars will receive both reflections and produce a real and a false target, separated by the time and azimuth difference between the two reflections.

d. ATCRBS is associated with FAA ASR and ARSR radars, but at times, ATCRBS is a standalone system. ATCRBS is also called Secondary Radar (SECRA), Radar Beacon (Beacon), interrogator (ground), transponder (aircraft) and the military versions Identification, Friend or Foe (IFF) and the DOD Selective Identification Feature (SIF) modified IFF. In ATC functions, the ATCRBS usually is tied to a primary radar and its PRR is equal to or a submultiple of the primary's PRR. In the case of staggered PRR, there is a basic clock relationship between the radar and the interrogator.

e. There are a number of problems which may be considered as "interference" in the broad sense. The FMO must be aware of them and their consequences as part of the PRR selection process and interference reporting.

(1) Ringaround is an aircraft transponder being interrogated by antenna side lobes causing elongated targets on the radar scope, as shown in figure 13-1. The effect is reduced or eliminated by SLS.

(2) False targets can be caused by either synchronous airborne replies to another beacon or reflections of the main beam energy. Aircraft transponders can reply to more than one interrogator and thus the beacon ground system can receive signals with various PRR's. A defruiter will eliminate nonsynchronous PRR FRUIT, but it will not reject synchronous PRR replies so that false targets appear on the display. This problem can best be controlled by geographical separation of similar PRR beacon systems. False targets are also caused by reflections of the main beam signal off large metal objects (e.g., a hangar), such that an aircraft outside the main beam is interrogated (see figure 13-2). SLS and interrogator power reduction will help reduce this phenomenon. (See Orders 6310.6, Primary/Secondary Terminal Radar Siting Handbook; 6340.15, Primary/Secondary En Route Radar Siting Handbook; 6360.12, ATCRBS Performance Handbook.)

(3) Second time around signals are those which show up on the scope even though they are beyond the distance of the actual target. It is caused by the interrogator signal going beyond its intended range and being received during the "next" receive pulse period of the radar, thus showing in the designed range, but actually being at a much greater distance. Various stagger and other fixes have eliminated most of this problem, but it does occur on occasions.

(4) Broken or serrated targets can be caused by synchronous PRR and by overinterrogation, causing reduction in sensitivity such that only the strongest interrogation will be answered. It is best controlled by low PRR assignments, proper PRR separation, interrogator power reduction, and periodic inspection of FAA and DOD interrogator assignments to assure minimum necessary use.

(5) Defective responses can plague the FMO which are not actual interference from another source. The ability to diagnose the difference is an art that comes from training and experience. ASR can supply data. A good information source is the radar engineering group in the regional office.

FIGURE 13-1. DISPLAY TIME EXPOSURE FOR A RADIAL FLIGHT SHOWING RINGAROUND

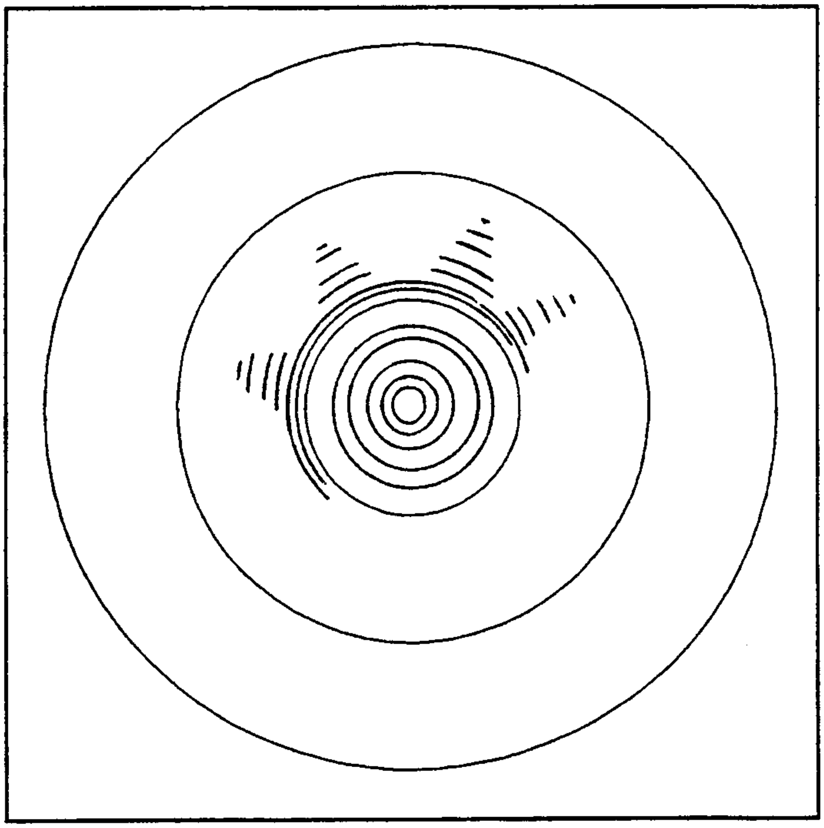
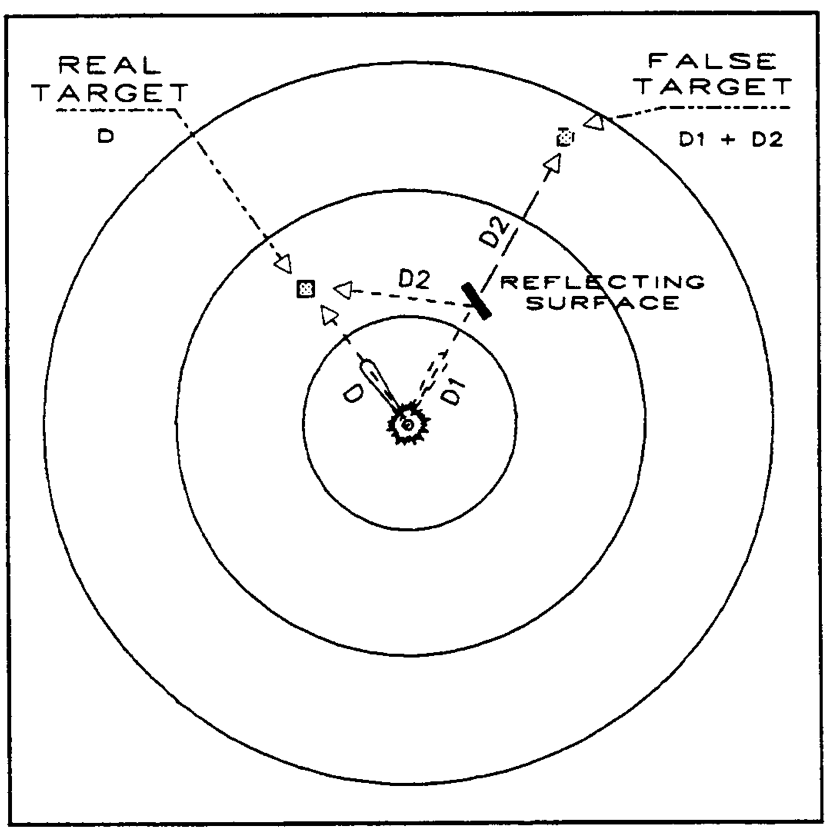


FIGURE 13-2. DISPLAY VIEW OF A REAL AND A FALSE TARGET



f. From the radar engineer's perspective, the highest possible PRR is desirable so that the hits-per-scan can be high. That function is an important parameter in radar operation. But from the FMO's view, the lowest PRR is ideal, to keep the ATCRBS spectrum as free from congestion as possible. (Primary radar PRR for many of the modern ASR and ARSR radars is staggered).

g. Care must be taken to separate assigned PRR's by a sufficient amount to assure noninterference. This is really a function of time and thus is a pulse period variant. But in the 350-370 pps non-stagger range of the ARSR-1 and -2, a PRR difference of 5 pps is sufficient. The standard PRR's for these radars are 350, 355, 360, 365 and 370 pps. Non-stagger radar beacons associated with ASR types normally use a PRR from 323-400 pps, e.g., ASR-8.

h. The same frequency pair (1030/1090 MHz) is also used by DOD IFF/SIF. But many of their older radars have PRR's that come out in odd numbers and decimals, due to the multivibrator oscillators used to generate the PRR. There is another problem with that type of radar. Besides drifting some because it is not crystal controlled, such military radars operate on harmonics of the oscillator. As a result, PRR can be transmitted at a much higher or lower rate than authorized, if the Nth harmonic is inadvertently tuned up. This has happened in the past. Hopefully, this will gradually diminish as old radars are phased out and newer stable and staggered PRR's are introduced in the new equipment.

1303. PRR ASSIGNMENT PROCESS. There is a series of procedures and precautions involved in making a new or modified PRR assignment.

a. The FAA is designated by the NTIA as the national coordinator for the 1030/1090 MHz frequency pair. This includes DOD as well as non-Federal users. Non-Federal users include contractors developing and testing radars for the Federal Government. All non-Federal assignments are considered experimental.

b. New PRR requests require careful review of the PRR assignment program, in light of the location, equipment type and PRR parameters requested. This will consist primarily of consulting the geographic/PRR list retained in the FMO's office and utilizing these guidelines:

(1) When a PRR is engineered for a non-FAA requestor, the requestor shall be advised of the FMO's recommended PRR. The requestor's IRAC or FCC application must show that coordination has been effected with the FMO.

(2) When a PRR is engineered for an FAA facility, an IRAC application will be filed in the usual manner.

(3) If a suitable PRR is not found, the FMO shall notify the requestor of the problem, advising the requestor that it will be necessary to adjust parameters so that another search may be made. To the extent possible, the FMO should offer suggestions as to what parameters might permit the recommending of a new PRR. Advise ASR if none is found.

c. The national standard maximum PRR is 450 pps and must not be exceeded.

d. Engineering procedures for a fixed PRR for an interrogator are:

(1) Beacon paired with a primary radar:

(a) The first step in engineering a beacon PRR is to determine the paired primary radar's PRR capability (see figure 13-3). The interrogator PRR is equal to or a submultiple of the primary radar to which it is paired.

(b) The second step is to determine whether the new interrogator is an en route (200 nmi) or a terminal (60 nmi) facility.

<u>1</u>. En route radars shall be assigned PRT's that differ by at least 25 microseconds (μsec) when located within 320 nmi of each other.

<u>2</u>. Terminal radars shall be assigned PRT's that differ by at least 25 μsec within 200 nmi of each other.

(2) A stand alone beacon uses the same procedure, except the primary PRR is not considered.

e. Engineering a staggered PRR for an interrogator is essentially the same as for a fixed PRR. Offset staggered PRR sequences must be used when an en route facility is within 320 nmi and a terminal facility within 200 nmi. Instead of having a 25 μsec or greater PRT separation, the stagger sequence for sequential pulses serves the same purpose.

f. ATCRBS or IFF/SIF interrogator power must be reduced to the lowest possible level. The higher the power, the more aircraft are interrogated and generate replies, cluttering the ATCRBS environment. In practice, it has been found that 60 to 100 W is sufficient for most 60 nmi terminal systems. The maximum permissible power that can be used by en route radars such as the ARSR series is 52.5 dBW (approximately 1,500W). However, with the advent of the FAA Technical Center (FAATC) Dipole Feed (NADIF) antenna and later other models, a power of only 250 W will still provide good system coverage while reducing overinterrogation of the system. DOD IFF/SIF systems frequently try to use 500 to 1,000 W. The FMO must ensure that only the minimum power needed to do the job is all that is used, whether it is associated with ARSR, ASR, DOD radar or stand-alone.

g. Special care must be taken when dealing with some DOD radars whose antennas have very broad beam widths. Some systems, particularly older models or those used in training have small antennas for portability. This helps them in rapidly moving the equipment around, but unfortunately the result of the smaller antenna is a much broader beam width. Instead of 1° or 2° maximum beam width of FAA ATCRBS antennas, some of the older military portable units have as much as 8° beam width. This multiplies the number and duration of interrogations of aircraft, adding unnecessary congestion. NTIA does not now have antenna beam width standards (see NTIA Manual).

h. DOD training maneuvers may present the FMO with interference problems. While the

FMO does not have the authority to specify beam widths, NTIA requires that the FMO be advised when maneuvers are to be held in an FMO's region. An alert is thus received to the possibility of ATCRBS interference through overinterrogation. The FMO will coordinate the DOD training radar usage, e.g., power, PRR, etc., and seek the advice of ASR as needed. In the event of an actual problem of this kind, the FMO shall immediately contact the appropriate DOD AFC and ASR.

FIGURE 13-3. RADAR AND ASSOCIATED BEACON CAPABILITIES

RADAR	PRR CAPABILITIES	ASSOCIATED BEACON PRR
AN/CPN-4	1500	300
AN/FPN-47	See ASR-5	See ASR-5
AN/FPS-7	244	Same as primary radar
AN/FPS-18	1200	300
AN/FPS-20, -20A	350, 355, 360, 365, 370	Same as primary radar
AN/FPS-64, -65, -66, -67	340, 345, 350, 355, 360, 365, 370	Same as primary radar
AN/GPS-4	360	Same as primary radar
AN/GPN-12	See ASR-7	See ASR-7
AN/GPN-20	See ASR-8	See ASR-8
AN/MPN-13, -14	1100	275 (4:1 countdown from primary)
AN/MPS-11 360		Same as primary radar
AN/TPS-43	227, 250, 278 (3X stagger)	Same as primary radar
AN/TPS-43E	245, 250, 258 (6X stagger: 245.1, 235.3, 227.3, 278.6, 263.9, 258.4)	Same as primary radar
ARSR-1, -2	See figures 13-4, -5	Same as primary
ARSR-3	See figures 13-6	Same as primary
ARSR-4	See figure 13-8	Same as primary
ASR-4, -5, -6	810, 900, 1125, 1140, 1155, 1170, 1185	3:1 countdown from primary
ASR-7	See figures 13-10	See figure 13-10
ASR-8	See figure 13-11	See figure 13-11
ASR-9	See figure 13-13	See figure 13-13

1304. FREQUENCY ASSIGNMENT PROCESS IN THE 1215-1400 MHZ BAND. Except for the ARSR-4, the FAA radars in this band are limited to 1240-1370 MHz, but where joint-use is involved, a frequency can be assigned anywhere in the 1215-1400 MHz band.

a. The band 1240-1370 MHz. The majority of radars in this band are the FAA ARSR-1, -2, -3 and -4 and FPS series. The ARSR-1, -2 and FPS series radars have two channels each which may be assigned frequencies within 5-10 MHz since only one channel transmits at a time. The ARSR-3 is a diplex radar and requires two frequencies substantially separated (about 25 MHz) within the band. The ARSR-4 is a diplex radar which requires two frequencies separated by 83 MHz.

(1) The ARSR-1, -2, and FPS series are very high power and long-range radars. To the extent the terrain permits, they are sited on a clear, high point of terrain. This, of course, extends their RLOS to other long-range radars. In the plains area, this is not as much a problem as in the West or East.

(a) Frequency separation between these radars is usually satisfactory at 5 MHz for 100 nmi and 10 MHz for 50 nmi. These long range radars (200 nmi range) are usually not sited closer than about 100 nmi, unless terrain factors require closer siting. In these few cases, it will be necessary to give a wider frequency separation.

(b) Bandpass filters may have to be used on some older ARSR's to reduce the emitted spectrum to prevent interference to other nearby radars, or even to the ARSR's associated ATCRBS. Contact ASR for details.

(c) ARSR-1/2 staggered PRR's. Figures 13-4 AND 13-5 provide the average PRR and stagger PRT's for the ARSR-1/2 radars. The ARSR-1/2 normally uses the high (noted as "H" in the figure) rate PRR sequences, while the low rate (noted as "L" in the figure) sequences are available as a modification to the ARSR-1/2. Both low and high rates are available for the FPS type radars.

FIGURE 13-4. ARSR-1/2 STAGGERED PRR AND PRT VALUES (HIGH)

Num	HIGH/ LOW	Avg PRR (Hz)	Pulse Repetition Time (PRT) in ms PRT1	PRT2	PRT3	PRT4	PRT5	AVG PRT
00	H	352.61	2647	2836	2761	2609	3327	2836
01	H	354.48	2633	2821	2595	3310	3310	2821
02	H	356.38	2619	2806	2731	2582	3292	2806
03	H	359.29	2605	2791	2716	2568	3275	2791
04	H	360.23	2591	2776	2702	2654	3257	2776
05	H	362.19	2577	2761	2699	2540	3239	2761
06	H	364.17	2563	2746	2673	2526	3222	2746
07	H	366.17	2549	2731	2658	2513	3204	2731
08	H	368.19	2535	2716	2643	2499	3187	2716
09	H	370.23	2521	2701	2629	2485	3169	2701

FIGURE 13-5. ARSR-1/2 STAGGERED PRR AND PRT VALUES (LOW)

Num	HIGH/ LOW	Avg PRR (Hz)	Pulse Repetition Time (PRT) in ms PRT1	PRT2	PRT3	PRT4	PRT5	AVG PRT
00	L	279.88	3115	3939	3207	3481	4123	3573
01	L	281.06	3102	3923	3193	3467	4105	3557
02	L	282.33	3088	3905	3179	3451	4087	3542
03	L	283.53	3075	3889	3165	3437	4069	3527
04	L	284.82	3051	3871	3151	3421	4051	3511
05	L	286.12	3046	3853	3137	3405	4033	3495
06	L	287.36	3034	3837	3123	3391	4015	3480
07	L	288.68	3020	3819	3109	3375	3997	3464
08	L	289.94	3008	3803	3095	3361	3979	3449
09	L	291.29	2993	3785	3081	3345	3961	3433
10	L	292.65	2979	3767	3067	3329	3943	3417
11	L	293.94	2966	3751	3053	3315	3925	3402
12	L	295.33	2952	3733	3039	3299	3907	3386
13	L	296.65	2939	3717	3025	3285	3889	3371
14	L	298.06	2925	3699	3011	3269	3871	3355
15	L	299.49	2911	3681	2997	3253	3853	3339
16	L	300.84	2898	3665	2983	3239	3835	3324
17	L	302.30	2884	3647	2969	3223	3817	3308
18	L	303.67	2871	3631	2955	3209	3799	3293
19	L	305.16	2857	3613	2941	3193	3781	3277
20	L	306.65	2843	3595	2927	3177	3763	3261
21	L	308.07	2830	3579	2913	3163	3745	3246
22	L	309.60	2816	3561	2899	3147	3727	3230
23	L	311.04	2803	3545	2885	3133	3709	3215
24	L	312.60	2789	3527	2871	3117	3691	3199
25	L	314.17	2775	3509	2857	3101	3673	3183
26	L	315.66	2762	3493	2843	3087	3655	3168
27	L	317.26	2748	3475	2829	3071	3637	3152
28	L	318.78	2735	3459	2815	3057	3619	3136
29	L	320.41	2721	3441	2801	3041	3601	3121
30	L	322.06	2707	3423	2787	3025	3583	3105
31	L	323.62	2694	3407	2773	3011	3565	3090
32	L	325.31	2680	3389	2759	2995	3547	3074
33	L	326.90	2667	3373	2745	2981	3529	3059
34	L	328.62	2653	3355	2731	2965	3511	3043
35	L	330.36	2639	3337	2717	2949	3493	3027
36	L	332.01	2626	3321	2703	2935	3475	3012
37	L	333.78	2612	3303	2689	2919	3457	2996
38	L	335.46	2599	3287	2675	2905	3439	2981
39	L	337.27	2585	3269	2661	2889	3421	2965
40	L	339.10	2571	3251	2647	2873	3403	2949
41	L	340.83	2558	3235	2633	2859	3385	2934
42	L	342.70	2544	3217	2618	2843	3367	2918
43	L	344.47	2531	3201	2605	2829	3349	2903
44	L	346.38	2517	3183	2591	2813	3331	2887
45	L	348.31	2503	3165	2577	2797	3313	2871
46	L	350.14	2489	3149	2563	2783	3295	2856

(2) The ARSR-3 is a diplex radar (i.e., both channels on-the-air) requiring a pair of frequencies, one for each channel. Although they are time-sequenced to operate from different time-zeros, the two assigned frequencies should be separated at a minimum of 25 MHz. This could entail shifting other radars in the area to other frequencies in the band. The frequency pairs are engineered by ASR.

(a) The ARSR-3 associated beacon uses an identical staggered or nonstaggered trigger used by the ARSR-3 itself. Four fixed pulse repetition rates are available from a front panel selection. However, the PRT is expressed in nmi with the basic rate designated as "A." For example:
A = 238 nmi = 238 X 12.355 µsec = 2,940.5 µsec. Note that theoretically it would take a radar signal 12.355 µsecs to go out 1 nmi, hit a target and return the 1 nmi. If a value for "A" is chosen between 222 and 261 nmi, the four fixed intervals are selected automatically by the following trigger sequence:

A + 16, A, A - 8 and A - 16. For example: A = 238 nmi; the four fixed PRR's would be equivalent to 254, 238, 230 and 222 nmi.

(b) The staggered trigger sequence selected depends on the nmi range selected for "A." There are three stagger sequences available, known as Variable Interpulse Periods (VIP). They are VIP-8, VIP-7, and VIP-5 (see figures 13-6 and 13-7). If "A" is between 235 and 261 nmi, the sequence is VIP-8; if between 228 and 235 nmi, VIP-7; if between 222 and 228 nmi, VIP-5. The VIP number indicates the number of different pulse intervals.

FIGURE 13-6. ARSR-3 PRR CAPABILITIES

ARSR-3 OPERATIONAL PRR MODES

1. Stagger trigger (Normal selection)
2. Non-stagger trigger (Special)

STAGGER/NONSTAGGER TRIGGER PRR

Stagger Trigger PRR (three trigger sequences, determined by value of "A" in nmi)

VIP-8 - "A" = any nmi integer between 235 and 261

Sequence: A-32 nmi, A+24 nmi, A-16 nmi, A+8 nmi, A-8 nmi, A+16 nmi, A-24 nmi, A+32 nmi. (eight different PRT's)

VIP-7 - "A" = any nmi integer between 228 and 235

Sequence: A-24 nmi, A+24 nmi, A-16 nmi, A+8 nmi, A-8 nmi, A-8 nmi, A±0 nmi, A-24 nmi, A+40 nmi. (nine different PRT's)

VIP-5 - "A" = any nmi integer between 222 and 228

Sequence: A-16 nmi, A+8 nmi, Am16 nmi, A+24 nmi, A-16 nmi, A-8 nmi, A-16 nmi, A+40 nmi. (eight different PRT's)

Non-stagger PRR (four trigger sequences, determined by value of "A" in nmi)

"A" = any nmi integer between 222 and 261

Sequence: A+16 nmi, A nmi, A-8 nmi, A-16 nmi.

FIGURE 13-7. ARSR-3 AVERAGE VIP PRT'S

NMI	AVG PRT (usec)	AVG PRR (pps)	NMI	AVG PRT (usec)	AVG PRR (pps)
		VIP-8			
235	2904.43	344	249	3077.47	325
236	2916.79	343	250	3089.83	324
237	2929.15	341	251	3102.19	322
238	2941.51	340	252	3114.55	321
239	2953.87	339	253	3126.91	320
240	2966.23	337	254	3139.27	319
241	2978.59	336	255	3151.63	317
242	2990.95	334	256	3163.99	316
243	3003.31	333	257	3176.35	315
244	3015.67	332	258	3188.71	314
245	3028.03	330	259	3201.07	312
246	3040.39	329	260	3213.43	311
247	3052.75	328	261	3225.79	310
248	3065.11	326			
		VIP-7			
228	2816.94	355	233	2866.38	349
229	2829.30	353	234	2827.74	347
230	2841.66	352	235	2891.10	346
231	2854.02	350			
		VIP-5			
222	2742.81	365	226	2792.25	358
223	2755.17	363	227	2804.61	357
224	2767.53	361	228	2816.97	355
225	2779.89	360			

(3) The ARSR-4 is a diplex radar with two separate frequencies within the band which are paired using the pairing scheme in figure 13-8. It operates throughout the 1215-1400 MHz band.

FIGURE 13-8. ARSR-4 CRYSTAL OSCILLATOR, STABILIZED LOCAL OSCILLATOR (STALO) AND TRANSMIT FREQUENCIES

ODD GROUP CRYSTALS (MHz)

XTAL NO.	OSC. FREQ.	STALO FREQ.	SET 1 LOWER	SET 1 UPPER	SET 2 LOWER	SET 2 HIGHER
01	45.5929	1458.97	1215.58	1298.94	1255.94	1308.79
03	45.7548	1464.15	1220.76	1303.62	1231.12	1313.97
05	46.2402	1479.69	1236.29	1319.15	1246.65	1329.51
07	46.4021	1484.87	1241.47	1324.33	1251.83	1334.69
09	46.8876	1500.40	1257.01	1339.87	1267.37	1350.22
11	47.0494	1505.58	1262.19	1345.04	1272.54	1355.40
13	47.5349	1521.12	1277.72	1360.58	1288.08	1370.94
15	47.6967	1526.29	1282.90	1365.76	1293.26	1376.12
17	48.1822	1541.83	1298.44	1381.29	1308.79	1391.65
19	48.3440	1547.01	1303.62	1386.47	1313.97	1396.83

EVEN GROUP CRYSTALS (MHz)

XTAL NO.	OSC. FREQ.	STALO FREQ.	SET 1 LOWER	SET 1 UPPER	SET 2 LOWER	SET 2 HIGHER
02	45.6738	1461.56	1218.17	1301.03	1228.53	1311.38
04	45.8357	1466.74	1223.35	1306.21	1233.71	1316.56
06	46.3212	1482.28	1238.88	1321.74	1249.24	1332.10
08	46.4830	1487.46	1244.06	1326.92	1254.42	1337.28
10	49.9685	1502.99	1259.60	1342.46	1269.96	1352.81
12	47.1303	1508.17	1264.78	1347.63	1275.13	1357.99
14	47.6158	1523.71	1280.31	1363.17	1290.67	1373.53
16	47.7776	1528.88	1285.49	1368.35	1295.85	1378.71
18	48.2631	1544.42	1301.03	1383.88	1311.38	1394.24
20	48.4250	1549.60	1306.21	1389.06	1316.56	1399.42

b. The bands 1215-1240 and 1370-1400 MHz. Radars assigned in these bands will be primarily for DOD use (except the ARSR-4). In these cases, the FMO has the same responsibility under NTIA directive to provide just as adequate interference protection to DOD/DOD radars as provided for DOD/FAA adjacent systems. The FMO should work very closely with the appropriate DOD AFC to provide the best separation possible commensurate with good spectrum utilization and conservation.

1305. FREQUENCY ASSIGNMENT PROCESS IN THE 2700-3000 MHZ BAND. This band is not exclusive to FAA. The 2900-3000 MHz portion is used by FAA solely for the NEXRAD weather radar. The FAA is designated by NTIA as the field coordinator for the 2700-2900 MHz portion of the band which is for aeronautical radionavigation services, meteorological aids and the DOD area surveillance radars. Because of this field coordination authority, the FMO selects and recommends frequencies in the 2700-2900 MHz band for all agencies which have a requirement to use this band. Subsequently, the agency, not the FAA, is required to process their frequency request through NTIA for formal assignment with the proper FAA coordination note.

a. FAA 2700-3000 MHz assignments.

(1) In general, if a radar frequency being considered is not within RLOS to any other radar within ±10 MHz, the assignment should be acceptable. Reflections from mountainous terrain could cause interference, so two radars within reflection range should be separated 5 to 10 MHz to prevent problems. If one of the radars is not crystal controlled, periodic frequency checks should be made of it to prevent gradual drift onto the other radar's frequency.

(2) A diplex radar is designed to take advantage of the differences in propagation between two separated frequencies, and thus it is desirable to separate the two frequencies as much as possible.

(a) The ASR-7 is a diplex radar but only on the channels shown in figure 13-9.

FIGURE 13-9. ASR-7E PRIMARY RADAR FREQUENCY PAIRS

Channel A (MHz)	Channel B (MHz)
2705	2855
2710	2770
2710	2795
2715	2820
2720	2780
2720	2785
2725	2860
2730	2790
2740	2800
2750	2810
2755	2850
2760	2820
2760	2850
2765	2880
2770	2830
2770	2850
2780	2840
2790	2850
2800	2860
2810	2870
2820	2750
2820	2880
2820	2890
2830	2890
2830	2895

FIGURE 13-10. ASR-7 AND ASSOCIATED BEACON STAGGERED PRR AND PRT

EQP SET	PRR	PRT	PRR	PRT	PRR	PRT	PRR	PRT	PRR	PRT	PRR	PRT	PRR	PRT	PRR	PRT
RDR P	1200	833	1173	853	1120	893	1050	953	950	1053	713	1403	---	---	---	---
BCN P	554	1806	530	1886	436	2296	350	2859	447	2236	542	1846	525	1906	320	3129
RDR Q	1188	841	1161	862	1109	902	1039	963	940	1064	706	1417	---	---	---	---
BCN Q	548	1825	525	1905	431	2319	346	2889	443	2258	536	1865	519	1926	316	3160
RDR R	1176	850	1150	870	1098	911	1029	972	931	1074	699	1431	---	---	---	---
BCN R	543	1842	520	1924	427	2342	343	2916	438	2281	531	1883	514	1943	313	3192
RDR S	1164	858	1138	879	1086	920	1019	982	921	1085	692	1445	---	---	---	---
BCN S	537	1861	515	1943	423	2365	339	2946	434	2303	526	1902	509	1964	310	3223
RDR T	1152	866	1126	887	1075	929	1008	991	912	1095	684	1459	---	---	---	---
BCN T	532	1878	510	1961	419	2388	336	2973	430	2325	521	1920	545	1982	307	3254
RDR U	1140	875	1114	896	1064	938	996	1001	902	1106	677	1473	---	---	---	---
BCN U	527	1897	505	1981	415	2411	333	3003	426	2348	516	1939	449	2002	304	3286

Notes: PRR in pps
PRT in µsec
RDR = radar
BCN = beacon interrogator
Primary ASR-7 is 6X stagger; associated beacon is 8X stagger

AVERAGE PRR's

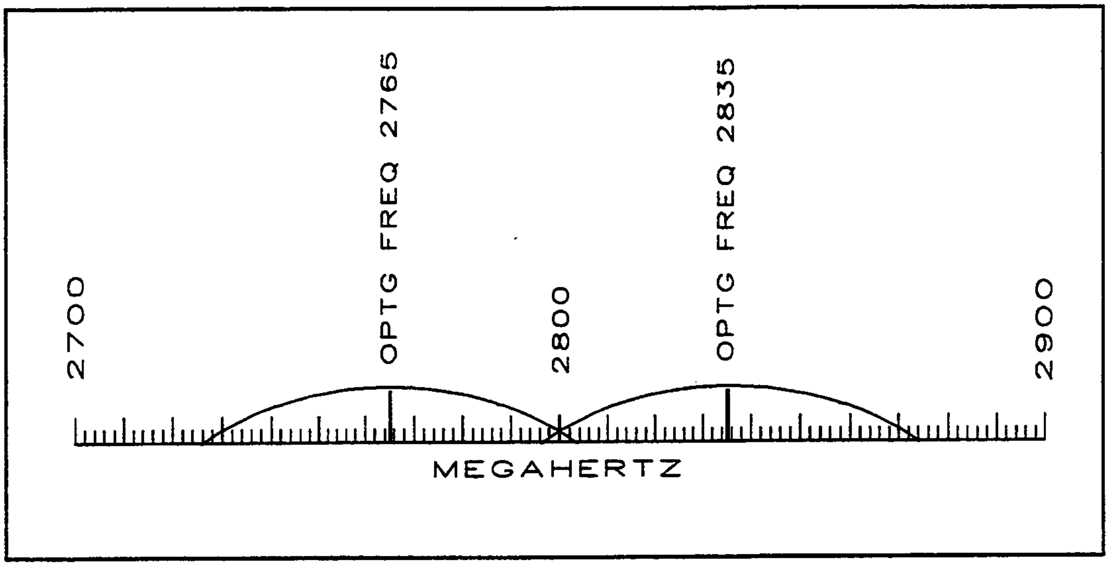
Set	Bcn Avg	Radar Avg
P	445	1002
Q	441	992
R	438	982
S	432	973
T	428	964
U	424	954

(b) **The ASR-8 dual channel radar** presents special problems in providing paired frequencies for it. The emitted spectrum of the transmitter is about ±10 MHz, about the same as the ASR-7. But the big problem is the receiver bandpass. Each receiver is approximately ±40 MHz wide. In addition, there is a manufacturer's limitation that the individual channels must be separated by an amount greater than 60 MHz. See figure 13-12. To fit ASR-8 diplex frequencies into an already congested environment presents the FMO with a very difficult task. Because changing a frequency in an ASR-8 requires replacing a whole transmitter package which includes oscillators and diplexer, a frequency change will be considered only as a last resort for an RFI problem remedy. Any ASR-8 frequency problem should be referred to ASR.

FIGURE 13-11. ASR-8 AND ASSOCIATED BEACON STAGGERED PRR AND PRT

PRR DESIG-NATION	AVG RADAR PRR	BEACON PRR 3:1 CNTDWN PPS / µSEC	RADAR 4X STAGGER SEQUENCE PRT (µSEC)			
BASIC	1040	347 / 2883	830	1177	876	961
0.5	1035	345 / 2898	835	1182	881	966
1.0	1030	343 / 2913	840	1187	886	971
1.5	1025	342 / 2928	845	1192	891	976
2.0	1020	340 / 2940	849	1197	896	980
2.5	1015	338 / 2958	855	1202	901	986
3.0	1010	337 / 2970	859	1206	905	990
3.5	1005	335 / 2985	864	1211	910	995
4.0	1000	333 / 3000	868	1216	915	1000
4.5	995	332 / 3015	874	1221	920	1005
5.0	991	330 / 3027	878	1225	924	1009
5.5	986	328 / 3042	882	1229	929	1014
6.0	981	327 / 3057	887	1234	934	1019
6.5	977	325 / 3072	892	1239	939	1024
7.0	973	324 / 3084	897	1244	943	1028

FIGURE 13-12. TYPICAL ASR-8 RECEIVER SUSCEPTIBILITY PASS BAND



(c) The ASR-9 radar is a single channel/dual frequency terminal radar. Only one channel, manually selectable by the operator, is on the air at any one time. Available crystals allow tuning throughout the band in 1 MHz increments between 2703-2987 MHz. PRR stagger sequences are shown in figure 13-13. While it is possible to have the ASR-9 channels as little as 10 MHz apart, it is advantageous to separate the channels by at least 50 MHz in order to allow frequency diversity to mitigate radio interference and anomalous propagation.

FIGURE 13-13. ASR-9 RADAR AND BEACON PRR'S

Beacon PRR, Normal mode

	Staggered PRR (per CPI pair)							Average PRR (per CPI pair) BCN	RADAR
00	440	440	514	514	342	514	330	429	1172
01	434	434	506	506	338	506	326	423	1156
02	434	434	506	506	338	506	326	423	1156
03	431	431	503	503	335	503	323	420	1148
04	428	428	499	499	333	499	321	417	1140
05	425	425	496	496	331	496	319	414	1132
06	422	422	493	493	328	493	317	411	1124
07	419	419	489	489	326	489	315	408	1116
08	417	417	486	486	324	486	312	406	1109
09	414	414	483	483	322	483	310	403	1101
10	411	411	479	479	320	479	308	400	1094
11	408	408	476	476	318	476	306	397	1087
12	406	406	473	473	315	473	304	395	1080
13	403	403	470	470	313	470	302	392	1073
14	400	400	467	467	311	467	300	390	1066
15	398	398	464	464	309	464	298	387	1059

Beacon PRR, VIP mode

	Staggered PRR, (per CPI pair)							Average PRR, (per CPI pair)	
16	436	433	513	512	340	511	329	426	1164
17	433	430	510	508	337	507	327	423	1156
18	430	427	506	505	335	504	325	420	1147
19	427	424	503	501	333	500	322	417	1140
20	424	421	499	498	330	497	320	414	1131
21	421	419	494	496	328	493	318	411	1124
22	418	416	492	491	326	490	316	408	1116
23	415	413	489	487	324	487	314	406	1108
24	413	410	486	484	322	483	312	403	1101
25	410	407	482	481	319	480	309	400	1094
26	407	405	479	478	317	477	307	398	1087
27	404	402	476	475	315	474	305	395	1080
28	402	400	473	471	313	471	303	392	1072

b. Non-FAA 2700-2900 MHz assignments.

(1) National Weather Service (NWS) Radars. Some of the older style weather radars operated by the NWS such as WSR-57 and WSR-74 still operate in this band. They are tunable but have rather poor spectra. Generally speaking, separation from FAA ASR series, except ASR-8, needs to be about 20 MHz, RLOS. In the case of the ASR-8, a clear band ±40 MHz for each channel frequency is required. Because of the relatively unstable operating parameters of those older radars, they need to be checked on a case-by-case basis. The entire NWS inventory is being replaced by joint DOD/FAA/NWS NEXRAD, also known as WSR-88D. NEXRAD installations must be coordinated carefully between FAA/NWS, particularly, the site locations.

(2) DOD Radars. Most of the DOD permanent requirements in this band will be for radars which are the DOD equivalents of FAA radars, such as the AN/GPN12 (ASR-7) and AN/GPN20/GPN27 (ASR-8). Assuming these are in ATC use around military bases, the FMO shall give the same protection and availability as FAA and NWS radars. Should the request be for tactical or training purposes, that function is secondary to all others and may be accommodated only if there is space without crowding or moving any of the ATC or NWS radars.

(3) Non-FAA/non-NWS/non-DOD Radars. This group will be very small, and all will be secondary and handled on a case-by-case basis, in coordination with ASR.

1306. **FREQUENCY ASSIGNMENTS IN THE 5600-5650 MHZ BAND**. TDWR presently is the only radar which FAA operates in this band. The band is shared with various weather radars operated by the DOD and NWS. TDWR's are normally sited off the airport which they serve in order to provide better surveillance in the area of that airport. Therefore, in some cases, TDWR's are located adjacent to public facilities and FMO's need to take special care that pre-commissioning radiation measurements are known and documented. When engineering an operating frequency for the TDWR, a circle search using the GMF and taking into account assigned frequencies as low as 5.4 GHz must be made in order to ensure compatibility with existing radars in the band 5.600-5.650 GHz as well as wide band radars operated by other agencies in the spectrum below 5.6 GHz. In addition, when siting TDWR's, in the vicinity of ASR's, the second harmonic relationship between 2.700-2.900 GHz band and the 5.600-5.650 GHz band must be considered.

1307. **FREQUENCY ASSIGNMENTS IN THE 9000-9200 MHZ BAND.** FAA currently has no radars in this band. The band is used principally by the military for Precision Approach Radar (PAR). Under the NTIA coordination assigned FAA, the FMO technically engineers and recommends a frequency for the DOD requestor, just as with the other bands in this chapter. However, since the FMO normally is not familiar with these DOD radars, it is best to coordinate with the appropriate DOD AFC and use the DOD's expertise in this area as FAA's recommendation. Should any user of this band contact the FMO reporting interference, the FMO shall take the lead in resolution of the problem as NTIA field coordinator.

1308. **FREQUENCY ASSIGNMENTS IN THE 15.7-16.2 GHZ BAND**. This band is used by FAA for Airport Surface Detection Equipment (ASDE) but is shared with and subject to coordination with DOD as coequal. Non-Federal users are permitted in this band on a noninterference basis to ASDE. For all ASDE frequency assignments, the FMO shall coordinate with ASR. ASDE's are designed to frequency hop within one of the four subbands 15.7-16.2, 16.2-16.7, 16.7-17.2 or 17.2-17.7 GHz, although FAA's current frequency allocation only allows primary operation in the 15.7-16.2 band.

1309. thru 1399. RESERVED.